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8.	ABSTRACT Abstract should not contain any [E.g. !@ #$%^&*() etc. and more than 2048 characters will not be acceptable]	This proposed research study aims to identify key physical, physiological, and psychological variables that predict performance in badminton and develop a discriminant model to classify players into singles or doubles categories based on these variables. The study will involve 60 national-level male badminton players (30 singles and 30 doubles players), aged 18–25 years, with at least five years of training and two years of national-level match experience. The selected variables include physical attributes (body height, arm length, leg length, reaction time, flexibility, shoulder strength, explosive leg strength, grip strength, and thumb pinch), physiological factors (body composition: fat percentage and muscle mass), and psychological traits (anxiety and emotion regulation). Data will be collected using standardized instruments such as a stadiometer, anthropometer rod, dynamometers, and validated questionnaires

		like the Sports Competition Anxiety Test (SCAT) and Emotion Regulation Questionnaire (ERQ). **Descriptive statistics will summarize the data, while multiple discriminant analysis will be employed to classify players into singles or doubles categories based on the predictor variables. The study hypothesizes that a significant discriminant model can be developed to distinguish between the two player categories, aiding in early talent identification and specialized training.** **The findings will provide valuable insights for coaches and trainers to optimize player selection, role-specific training, and performance enhancement strategies. By identifying dominant variables, the study will contribute to the scientific understanding of badminton performance and support the development of tailored training programs for aspiring athletes.**
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A MODEL FOR DISCRIMINATING BADMINTON PLAYER BASED ON PHYSICAL, PHYSIOLOGICAL, AND PSYCHOLOGICAL PARAMETERS

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SHORT SYNOPSIS

Submitted in partial fulfilment of the requirements of the degree of

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to

Departmental Research Committee

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Certificate

I hereby declare that the short synopsis titled "**A Model for Discriminating Badminton Player Based on Physical, Physiological, and Psychological Parameters"** being submitted in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Physical Education from Lakshmibai National Institute of Physical Education, NERC, Guwahati during academic year 2021-22.

It is a bonafide record of original work carried out under the supervision of Dr. Sujay Bisht and has not been submitted in full or in part to any other university or institute for a degree or diploma. Further, it is certified that the short synopsis is plagiarism-free, and proof has been submitted.

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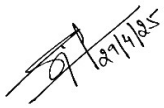

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ABSTRACT

This proposed research study aims to identify key physical, physiological, and psychological variables that predict performance in badminton and develop a discriminant model to classify players into singles or doubles categories based on these variables. The study will involve 60 national-level male badminton players (30 singles and 30 doubles players), aged 18–25 years, with at least five years of training and two years of national-level match experience.

The selected variables include physical attributes (body height, arm length, leg length, reaction time, flexibility, shoulder strength, explosive leg strength, grip strength, and thumb pinch), physiological factors (body composition: fat percentage and muscle mass), and psychological traits (anxiety and emotion regulation). Data will be collected using standardized instruments such as a stadiometer, anthropometer rod, dynamometers, and validated questionnaires like the Sports Competition Anxiety Test (SCAT) and Emotion Regulation Questionnaire (ERQ).

Descriptive statistics will summarize the data, while multiple discriminant analysis will be employed to classify players into singles or doubles categories based on the predictor variables. The study hypothesizes that a significant discriminant model can be developed to distinguish between the two player categories, aiding in early talent identification and specialized training.

The findings will provide valuable insights for coaches and trainers to optimize player selection, role-specific training, and performance enhancement strategies. By identifying dominant variables, the study will contribute to the scientific understanding of badminton performance and support the development of tailored training programs for aspiring athletes.

Keywords: Badminton, Discriminant Analysis, Performance Prediction, Physical Variables, Physiological Variables, Psychological Variables.

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CHAPTER I

INTRODUCTION

Currently, sports have become integral to our culture. It is both impacted by and exerts influence on all our social institutions, including education, economics, the arts, politics, law, mass media, and international diplomacy. The extent of its span is remarkable. Many sports have evolved into a medium of public communication, while others are being embraced as fashion by certain individuals. They draw large crowds for leisure, physical fitness, or as a full-time vocation.

Physical education and activities such as sports, as essential components of education, have likewise been influenced by scientific progress. Currently, participating in national or world championships is challenging unless individuals select sports that align with their physiological, mental, and psychological capabilities and engage in a methodical training regimen accordingly.

As competition intensifies and standards in sports elevate, the identification of talent is crucial; young athletes must be recognized early and provided with appropriate scientific instruction to achieve exceptional performance. Even the most talented athlete may fail to deliver exceptional performance if not selected for the sport at the appropriate moment. It is akin to inserting a specific component into an object.

Recent advancements in the realm of sports and gaming achievements have witnessed significant transformations. Athlete performance has become a focal point of extensive scrutiny, playing a pivotal role in achieving excellence across diverse field games and sports. Athletes consistently demonstrate exceptional outcomes, facilitated by the integration of novel scientifically-grounded training methodologies and advancements in sports performance mediums, including tactical and technical innovations alongside advancements in sports training systems and equipment.

The determination of athletic success, gauged through competitive performance, hinges on several prominent factors: physical, physiological, psychological, age, nutritional status, training proficiency, and genetic predisposition. Presently, meticulous attention is devoted in every sport to identifying diverse physiological and anthropometric variables that influence

elite athlete performance. Research findings underscore that each sport showcases athletes possessing distinctive physiological and anthropometric attributes that enhance performance within their respective disciplines.

Multiple factors contribute to the enhanced performance of athletes, necessitating the collaborative efforts of various disciplines within sports science to investigate the nature and processes of sports performance. In recent decades, various specialties within sports sciences, including sports therapy, sports physiological science, sports anatomy and physiology sports psychology, and sports nutrition, have arisen. Sports sciences function as a cohesive entity, assisting athletes in attaining optimal performance (Ali, 2003). Additionally, physical education encompasses the entirety of human physical activities, chosen for their nature and executed for certain ends.

Badminton is a racket sport contested by either two individual players (singles) or two pairs of players (doubles), who occupy opposing halves of a rectangular playing surface separated by a net. Players accumulate points by hitting a shuttlecock with their racket, ensuring it crosses the net and lands in the other side of the court. A rally concludes when the shuttlecock contacts the ground, and each side may strike the shuttlecock just once until it crosses the net.

The shuttlecock, or shuttle, is a feathered projectile with distinct aerodynamic characteristics that result in a flight pattern divergent from that of balls utilized in most racket sports; specifically, the feathers generate significantly greater drag, leading to a more rapid deceleration compared to a ball. Shuttlecocks exhibit a significantly higher maximum velocity in comparison to other racquet sports. The trajectory of the shuttlecock is significantly influenced by wind; hence, competitive badminton is exclusively played inside. Badminton is additionally played outside as a leisurely recreational pursuit, frequently in garden or seaside settings.

Since 1992, when badminton has served as an Olympic discipline with 5 events: men's singles, women's singles, men's doubles, doubles for women, and mixed doubles, the latter involving a male and a female participant in each combination. At advanced levels of competition, the sport necessitates superior physical conditioning: athletes must possess aerobic endurance, agility, strength, velocity, and accuracy. It is a technical sport that necessitates proficient motor control and the cultivation of advanced racket maneuvers.

STATEMENT OF THE PROBLEM

The purpose of the present study is to identify badminton performance predicting variables based on their specialty and then develop a discriminant model for classifying badminton players for singles and doubles based on selected physical, physiological, and psychological variables.

OBJECTIVES OF THE STUDY

Following are the objectives of the study:

1. To measure the physical, physiological, and psychological variables of badminton players.
2. To find out factors as well as the variables (physical, physiological, and psychological) that may prove their dominance in the classification of players.
3. To find out whether the subjects could be classified into their area of specialty based on identified variables that have proven their dominance to predict players in an early stage of their badminton carrier.
4. To find out among all the identified predicted variables, which predictor variables have more discriminating power to classify the badminton players based on their area of specialty.

DELIMITATIONS

The research scholar will confine this study within the following delimitations:

1. The study will be delimited to a minimum of 60 National level male badminton players with at least 5 years of training experience and a minimum of 2 years of match experience in national-level tournaments.
2. The present study will be further delimited to players of two different areas of specialty i.e., singles and doubles.
3. The study will further be delimited to the following physical, physiological, and psychological variables for predicting badminton performance: -

Physical: Body Height, Arm Length, Leg Length, Reaction time, Flexibility, Shoulder strength, Leg explosive strength, Grip strength, and Thumb Pinch

Physiological: Body Composition (Fat % & Muscle Mass)

Psychological: Anxiety, and Emotion Regulation

HYPOTHESES

It is hypothesized that there would be a significant multiple discriminant model developed for classifying a badminton player for singles or doubles based on selected predictor variables.

DEFINITION AND EXPLANATION OF THE TERMS

Badminton

Badminton is a racquet sport in which players use racquets to strike a shuttlecock over a net. The game can be played with larger teams, although the predominant formats are "singles" (one player per side) and "doubles" (two players per side).

Height

A person's height or stature is the vertical measurement from the soles of the feet to the crown of the head in an upright position. It is quantified with a stadiometer, in centimeters within the metric system, or in feet and inches.

Arm length

It is defined as the distance between the acromion process to the distal phalanx of the third digit.

Leg length

It is defined as the distance between the greater trochanter to the lateral edge of the foot.

Muscle Mass

Muscular mass denotes the quantity of soft muscular tissue present in the body.

Fat

It is a dense energy source, providing 9 calories per gram.

Anxiety

It is commonly characterized as an unpleasant psychological condition resulting from perceived stress related to task performance under pressure, frequently encountered by athletes across all performance levels.

Emotion Regulation

It refers to the capacity to manage one's emotional state. It may encompass activities such as reframing a difficult circumstance to mitigate anger or anxiety, concealing overt manifestations of grief or fear, or concentrating on factors that induce happiness or tranquility.

Reaction time

It is the duration that transpires between the initiation or presentation of a stimulus and the subsequent manifestation of a specific response to that stimulus.

Flexibility

It is the capacity of a joint or a collection of joints and muscles to move efficiently within an unimpeded and pain-free possible range of motion.

Shoulder Strength

It is the maximal force created to prevent maximal load movement by a particular muscle group or a combination of muscle groups.

Explosive Leg Strength

The capacity to generate maximal force in the minimal time frame.

SIGNIFICANCE OF THE STUDY

The study may be significant in the following ways:

1. This research will serve as a valuable resource for identifying the key physical, physiological, and psychological parameters that differentiate athletes participating in singles versus doubles categories in badminton.
2. The investigation aims to develop a discriminant function capable of categorizing individuals into either the singles or doubles group, based on measurable predictor variables.
3. The outcomes of the study will offer insights into the relative contribution of each predictor variable in effectively distinguishing between the two competitive formats.
4. The findings will support coaches and trainers in the strategic selection and preparation of badminton athletes, aligning training practices with the distinct demands of singles and doubles play.
5. The results will contribute to the design and implementation of role-specific training programs for badminton players, optimizing performance based on positional requirements.
6. The study's implications will further assist in determining an athlete's most suitable event—singles or doubles—through assessment of their physical, physiological, and psychological profiles.
7. This research will also provide a framework for coaches to evaluate and select emerging badminton players by considering their limitations and potential across the identified performance-related variables.

CHAPTER II

REVIEWS OF RELATED LITERATURE

The academic researcher endeavored with maximum diligence to comprehensively examine the most salient and applicable scholarly corpus available. Throughout this methodological investigation, the subject engaged in extensive analysis of antecedent empirical findings which demonstrated correlational significance to physical, physiological, and psychological parametric indicators relevant to the establishment of predictor variable frameworks specific to Badminton performance metrics. The literature reviews subsequently referenced herein encompass multidisciplinary domains including physical anthropometric assessment, physiological functional capacity evaluation, and psychological performance attribute measurement. Additionally, the cited research encompasses methodologically sophisticated studies employing discriminant analysis statistical techniques specifically designed to isolate and quantify predictive variables demonstrating statistical significance in relation to athletic performance outcomes across diverse sporting disciplines. This comprehensive literature review constitutes a fundamental prerequisite for the establishment of a robust theoretical framework upon which subsequent hypothesis formulation and experimental design can be predicated.

In a scholarly investigation conducted by **Ramesha, N. (2020)**, the researcher implemented a methodological framework designed to assess the correlational significance between predetermined anthropometric parameters, motor ability indices, psychological constructs, and performance-based skill execution among male badminton practitioners. The investigator's sample population comprised eighty-five (N=85) competitive badminton athletes who participated in the inter-zonal tournament administered by the Visvesvaraya Technological University within the Karnataka geographical region during the 2017-2018 academic calendar period. Cognitive decision-making processes and intelligence quotient measurements were quantitatively evaluated utilizing validated psychometric assessment instruments, while reaction time variables were precisely measured via digital chronometric apparatus, and badminton-specific technical proficiency was assessed through standardized performance-based evaluation protocols. Following comprehensive data acquisition, statistical hypothesis

testing was conducted independently for each experimental variable. The methodological statistical framework employed for quantitative analysis incorporated regression modeling techniques, descriptive statistical measures including measures of central tendency and dispersion, and inferential statistical procedures, specifically Pearson product-moment coefficient correlation analyses. Statistical significance thresholds were established at $\alpha = 0.05$ across all analytical procedures. The empirical findings demonstrated statistically significant positive correlational relationships between anthropometric measurements, motor ability parameters, and psychological variables with badminton skill performance metrics. Conversely, specific motor ability variables exhibited significant negative correlational relationships with badminton performance indicators. Additionally, the analysis revealed non-significant statistical relationships between thoracic circumference expansion measurements, simple reaction time to auditory stimuli (SRT-Sound), and select decision-making subcomponents when evaluated against any performance-based skill execution metrics in badminton practitioners.

Bisht, Heera Singh (2019) conducted a comprehensive scientific investigation designed to establish a multidimensional profile encompassing physiological parameters, physical anthropometrical indices, and psychological constructs specific to badminton competitors indigenous to the Uttarakhand geographical region. This research was precipitated by the significant paucity of empirical data regarding the comprehensive profiling of Uttarakhand badminton practitioners across these critical performance domains, thus creating a substantial lacuna in the scientific literature. The experimental cohort consisted of sixty (N=60) competitive badminton athletes from Uttarakhand, with chronological ages not exceeding nineteen years. The subject population demonstrated consistent participation in formalized badminton competitive events over multiple sequential competitive seasons within their respective tournament classifications. The physiological parameters selected for quantitative assessment included maximal inspiratory breath-holding capacity, maximal expiratory pressure measurement, and resting cardiovascular endurance as measured through basal heart rate monitoring. The physical performance variables subjected to measurement encompassed locomotor velocity (Speed), musculotendinous extensibility (Flexibility), multidirectional movement efficiency (Agility), and upper extremity muscular force production capacity (Arm strength). Anthropometric measurements implemented in the research protocol included vertical stature (Standing Height), femoral longitudinal dimension (Upper Leg Length),

humeral longitudinal dimension (Upper Arm Length), brachial circumference (Arm Circumference), shoulder width (Biacromial Breadth), thigh circumference (Upper Leg circumference), and articular dimension at the elbow joint (Elbow Breadth). The psychological constructs evaluated included competitive anxiety state and achievement motivation orientation. The quantitative data acquired from the experimental subjects underwent rigorous statistical analysis utilizing descriptive statistical methodologies, including measures of central tendency (mean), dispersion (Standard Deviation), and distribution characteristics (skewness and kurtosis) to establish normative values for the population under investigation.

Carlos Lago-pen˜as et al. (2018) conducted a comprehensive empirical investigation designed to establish comprehensive anthropometric and physiological normative profiles for adolescent soccer practitioners, stratified according to their tactical positional specialization, while concurrently determining the statistical relevance of these parameters for competitive performance outcomes. The research cohort comprised three hundred and twenty-one (N=321) adolescent male soccer athletes who were methodologically categorized into the following positional classifications: Goalkeeping specialists (n=35), Central Defensive positions (n=53), External Defensive positions (n=54), Central Midfield operatives (n=61), External Midfield specialists (n=46), and Offensive Forward positions (n=72). An extensive anthropometric assessment protocol was implemented, incorporating precise measurements of vertical stature, body mass, body mass index calculation, hexagonal skinfold assessment at six anatomical sites, quadrilateral skeletal diameter measurements at four anatomical landmarks, and circumferential measurements at three anatomical loci. Additionally, somatotypic classification and comprehensive body composition analysis (quantifying absolute mass values and relative percentages of adipose tissue, osseous structures, and muscular components) were systematically calculated. The physiological assessment battery included the 20-meter progressive shuttle run protocol for the estimation of relative maximal oxygen consumption ($\dot{V}O_2max$), a 30-meter linear sprint velocity assessment on a non-inclined surface, and a tripartite lower extremity power assessment incorporating three distinct vertical jump protocols (concentric-only squat jump, stretch-shortening cycle countermovement jump, and the Abalakov test with arm swing contribution). The morphological analysis revealed that External Midfield specialists demonstrated the lowest adiposity indices and shortest stature measurements. Conversely, Central Defensive positions and Goalkeeping specialists were characterized by significantly greater vertical stature and body mass measurements, with

concomitantly larger subcutaneous adipose tissue deposits as measured by skinfold assessments. Generally, the empirical findings demonstrated that adolescent soccer practitioners with greater body mass and vertical stature exhibited superior performance in vertical displacement and linear sprint velocity assessments, whereas athletes with lower adiposity indices demonstrated enhanced performance in the 20-meter progressive aerobic capacity assessment. The competitive performance stratification involved dichotomization of the participants according to their respective team's terminal competitive ranking at the conclusion of the competitive season. Athletes from higher-performing teams demonstrated marginally superior performance metrics in physiological assessments compared to their counterparts from lower-performing teams; however, these inter-group differences failed to achieve statistical significance thresholds. Furthermore, practitioners from higher-achieving teams demonstrated significantly lower adiposity indices and greater muscular development compared to their counterparts from less successful competitive squads.

Sandeep, S (2018) implemented a methodological research protocol designed to quantify the efficacy of Dynamic Sports Vision Training interventions on visual physiological parameters and sport-specific technical proficiency among elite badminton practitioners. The experimental methodology incorporated an initial pilot investigation conducted on a limited cohort (n=10) to establish baseline measurements. Visual performance parameters and badminton-specific technical execution capabilities were assessed according to predetermined standardized protocols, with the resultant data utilized to establish the appropriate training stimulus intensity for the subsequent experimental intervention. The experimental subject population was randomly selected from the Thiruvananthapuram geographical district and subsequently randomized into two equivalent experimental conditions: a Dynamic Sports Vision Training intervention group (n=20) and a non-intervention Control condition (n=20). The dependent variables subjected to quantitative assessment comprised Static Visual Acuity measurement, Dynamic Visual Acuity assessment, Visual Perceptual processing capabilities, Visual-Motor integration parameters, and sport-specific technical executions including Badminton Short Serve precision and Backhand Drop Shot accuracy. The independent variable manipulation consisted of a systematically implemented Dynamic Sports Vision Training protocol. The measurement instrumentation employed for quantitative assessment included the Snellen Acuity Scale for static visual acuity determination, a non-instrumented Dynamic Visual Acuity assessment protocol, the Developmental Test for Visual Perception standardized for adolescent

and adult populations, the French Short Serve standardized assessment, and a validated Backhand Drop Shot performance evaluation protocol. The quantitative data acquired from both experimental conditions pre-intervention and post-intervention were subjected to rigorous statistical analysis utilizing Analysis of Covariance (ANCOVA) methodology. In instances where the calculated 'F' statistic for the adjusted post-test measurements achieved statistical significance thresholds, post hoc comparative analyses were deemed unnecessary due to the binary nature of the experimental design incorporating only two experimental conditions. Statistical significance was established at the 0.05 alpha level across all analytical procedures to minimize Type I error probability. The empirical findings demonstrated that the Dynamic Sports Vision Training intervention group exhibited statistically significant performance superiority compared to the non-intervention Control condition across nearly all dependent variables assessed. However, it is noteworthy that the research findings revealed no statistically significant differential improvement between the Dynamic Sports Vision intervention group and the Control condition specifically regarding Static Visual Acuity measures, suggesting that this particular visual parameter may be relatively resistant to training-induced adaptations or may require alternative intervention methodologies to elicit meaningful improvements among elite badminton practitioners.

Srinet, Mukti Singh (2017) executed a multifaceted scientific investigation designed to elucidate the correlational significance between anthropometric parameters, physiological indices, and psychological constructs in relation to performance metrics among male basketball practitioners. Additionally, the research aimed to quantify the combined statistical contribution of these multidimensional variables to basketball performance outcomes and to develop predictive mathematical models utilizing multiple regression statistical methodologies for the accurate forecasting of basketball performance capabilities among male basketball athletes. The anthropometric assessment protocol incorporated vertical stature measurement, body mass quantification, upper extremity longitudinal dimension, lower extremity longitudinal dimension, thoracic circumference, and gastrocnemius circumference, which were assessed utilizing standardized instrumentation including a calibrated Stadiometer, precision weighing apparatus, and inextensible anthropometric steel tape respectively. The physiological assessment battery encompassed arterial blood pressure measurement, cardiac chronotropic function at rest, pulmonary expiratory flow capacity, and body mass index calculation, which were quantitatively evaluated using a digital sphygmomanometric device, chronometric

measurement for cardiac contractions per unit time, and a calibrated peak expiratory flow measurement apparatus. The psychological construct assessment incorporated competitive sport-specific anxiety state and achievement motivation orientation, which were evaluated utilizing the standardized Sports Competition Anxiety Test (SCAT) developed by Rainer Martens and the Sports Achievement Motivation Test (SAMT) constructed by M.L. Kamlesh, respectively. The acquired quantitative data underwent statistical analysis utilizing Pearson product-moment correlation coefficient (r) to determine the statistical relationship between basketball performance metrics and each discrete anthropometric, physiological, and psychological variable. Multiple correlation statistical procedures were implemented to quantify the combined statistical contribution of the anthropometric, physiological, and psychological parameters to basketball performance outcomes. Additionally, regression equation modeling was conducted for the development of predictive algorithms from the anthropometric, physiological, and psychological variable matrices. The statistical analysis revealed statistically significant correlational relationships between male basketball performance metrics and the following variables: vertical stature, upper extremity longitudinal dimension, lower extremity longitudinal dimension, resting cardiac chronotropic function, pulmonary expiratory flow capacity, systolic arterial pressure, diastolic arterial pressure, body mass index, competitive sport-specific anxiety, and achievement motivation orientation. Conversely, the statistical relationship between body mass, thoracic circumference, gastrocnemius circumference, and basketball performance metrics among male basketball practitioners failed to achieve statistical significance at the predetermined 0.05 alpha level. Multiple correlation statistical analyses were computed to identify those anthropometric, physiological, and psychological variables demonstrating the highest predictive validity for basketball performance outcomes among male practitioners. The empirical findings indicated that vertical stature, body mass, upper extremity longitudinal dimension, lower extremity longitudinal dimension, thoracic circumference, and gastrocnemius circumference exhibited the greatest statistical contribution to basketball performance among the anthropometric parameter matrix. Within the physiological dimension, systolic arterial pressure, diastolic arterial pressure, resting cardiac chronotropic function, pulmonary expiratory flow capacity, and body mass index demonstrated the highest statistical contribution to basketball performance outcomes. Among psychological constructs, competitive sport-specific anxiety and achievement motivation orientation exhibited the greatest statistical contribution to basketball performance metrics.

Gangwar, Narendra (2017) implemented a systematic scientific investigation with the primary objective of establishing a multivariate discriminant function model for soccer practitioners operating at distinct tactical positions based upon predetermined anthropometric parameters, physiological functional capacities, and soccer-specific technical skill execution variables. The research cohort comprised two hundred and thirty-five (N=235) male soccer athletes affiliated with Sports Authority of India (SAI) specialized training facilities and developmental academies, with chronological age parameters ranging from fourteen to nineteen years, stratified into three discrete age classifications (Under-14, Under-16, and Under-19 chronological cohorts). Subject selection methodology employed a multistage probability sampling technique, with subsequent taxonomic classification into three positional categories (i.e., Offensive Attackers = 75, Central Midfielders = 75, and Defensive positions = 75). The variable selection protocol incorporated comprehensive literature review, consultation with domain-specific expertise, and researcher theoretical understanding, resulting in the identification of thirteen predictor variables distributed across three domains: six anthropometric parameters, five physiological functional capacity measures, and two soccer-specific technical skill execution variables. The statistical methodology employed for model development utilized Multiple Discriminant Analysis, a multivariate statistical technique specifically designed for classification of individuals into predetermined categorical groups based on a matrix of predictor variables. The empirical findings demonstrated that the Wilks' lambda statistical values calculated for all predictor variables approximated unity, indicating insufficient discriminatory power for inclusion in the final model. The position-specific analysis of the multiple discriminant function model revealed that offensive attackers, central midfielders, and defensive positional specialists demonstrated homogeneous characteristic profiles across positional classifications, as evidenced by the absence of statistically significant differences across all selected anthropometric parameters, physiological functional capacities, and soccer-specific technical skill variables. This homogeneity of player characteristics across tactical positions may be attributed to contemporary soccer training methodologies which implement standardized training protocols across all positional classifications rather than position-specific developmental approaches. The investigative scholar concluded that the discriminant function model developed for the three distinct tactical positions (i.e., offensive attackers, central midfielders, and defensive positions) failed to identify statistically significant differentiating variables between positional groups, resulting in no variables achieving sufficient discriminatory power for inclusion in the final discriminant function model. This finding suggests a high degree of morphological, physiological, and technical homogeneity

among contemporary developing soccer practitioners across traditional positional classifications, potentially reflecting the evolution of modern positional demands in soccer requiring multi-dimensional capabilities across all tactical roles.

Bagchi, Amritashish (2017) conducted a comprehensive scientific investigation designed to formulate and validate a multivariate discriminant function model for the taxonomic classification of cricket practitioners based upon predetermined anthropometric parameters and physical performance variables. The experimental cohort comprised one hundred and forty (N=140) male cricket specialists (chronological age: 24 ± 3.2 years) who were systematically categorized into two distinct functional classifications (i.e., Batting specialists n = 70 & Fast-Bowling practitioners n = 70). The experimental protocol incorporated a total of twelve predictor variables distributed across two domains: five anthropometric measurements and seven physical performance parameters, which were selected following rigorous methodological consideration. The statistical analysis revealed that the discriminant function model developed for differentiating between Batting specialists and Fast-Bowling practitioners demonstrated substantial statistical robustness as evidenced by elevated log determinant values. The discriminant function equation derived from the statistical analysis demonstrated significant explanatory power, accounting for 53.14% of the total variance in the dependent variable classification through the discriminant model. The classification matrices generated through this discriminant function demonstrated considerable predictive accuracy, with 82.1% of the experimental subjects being correctly classified into their respective functional specializations. The empirical findings from this investigation indicated that Fast-Bowling practitioners exhibited significantly greater vertical stature measurements and demonstrated superior upper extremity explosive power production capacity and lumbar-thoracic muscular force production capabilities compared to their Batting specialist counterparts. The physiological demands placed upon Fast-Bowling practitioners necessitate enhanced physical conditioning parameters relative to Batting specialists, as the biomechanical requirements and energy expenditure associated with individual bowling delivery execution demand superior strength development in the shoulder girdle musculature, lower extremity propulsive musculature, and vertebral stabilizing musculature. Conversely, left upper extremity grip strength measurements were significantly elevated among Batting specialists compared to Fast-Bowling practitioners; this physiological adaptation may be attributed to the task-specific biomechanical demands of cricket batting technique, wherein the superior hand (left hand for

right-handed batsmen) exerts predominant control during vertical ground-directed stroke execution compared to the inferior hand (right hand), resulting in asymmetrical strength development specific to the functional demands of batting technical execution.

Devaraju K. (2017) implemented a comprehensive scientific investigation with the primary objective of formulating a predictive statistical model for Kabaddi performance capability based upon predetermined anthropometric parameters and physical performance variables among collegiate-level practitioners. The experimental cohort comprised one hundred and forty-four (N=144) male intercollegiate Kabaddi specialists who were selected utilizing a stratified random sampling methodology from various tertiary educational institutions throughout the Tamil Nadu geographical region of India, with chronological age parameters ranging between eighteen and twenty-eight years. The subject inclusion criteria stipulated a minimum of three years of competitive Kabaddi participation history, with mandatory representation of their respective collegiate institutions in formalized competition. An extensive anthropometric assessment protocol was conducted on each experimental participant, incorporating vertical stature measurement utilizing a calibrated stadiometer, body mass quantification via precision weighing apparatus, and two longitudinal dimensional measurements—upper extremity length and lower extremity length—assessed utilizing standardized Lufkin Anthropometric inextensible tape. All anthropometric data acquisition procedures adhered rigorously to the standardized testing protocols established by the International Society for the Advancement of Kinanthropometry to ensure methodological validity and reliability. Physical performance parameters were assessed utilizing the following standardized protocols: locomotor velocity was evaluated via the 50-meter linear sprint assessment, musculotendinous extensibility was quantified using the Sit and Reach evaluation protocol, lower extremity explosive power production was assessed via the Standing Broad Jump horizontal displacement test, abdominal muscular power generation was measured through modified sit-up protocol, and cardiovascular-respiratory endurance capacity was evaluated using the 2.4-kilometer continuous running assessment. The criterion variable, Kabaddi performance capability, was evaluated through subjective assessment methodology by three qualified Kabaddi technical specialists with appropriate certification. All experimental testing protocols were implemented forty-eight hours prior to intercollegiate competitive participation utilizing scientifically validated assessment instrumentation. Descriptive statistical analysis, including measures of central tendency (mean) and dispersion (standard

deviation), was calculated for each experimental variable. The statistical interrelationships among the selected anthropometric parameters, physical performance variables, and Kabaddi performance capability were quantified utilizing Pearson's product-moment correlation coefficient analysis. All anthropometric and physical performance variables demonstrating statistically significant correlational relationships with the criterion performance variable were subsequently incorporated into respective linear predictive models utilizing stepwise multiple regression methodology. The empirical findings demonstrated statistically significant interrelationships between anthropometric parameters, physical performance variables, and Kabaddi performance metrics among male intercollegiate practitioners. Furthermore, the statistical analysis revealed that locomotor velocity, multidirectional movement efficiency (agility), body mass, and musculotendinous extensibility emerged as the predominant predictive variables that demonstrate the highest statistical power for predicting the performance capability of Kabaddi practitioners at the collegiate competitive level.

Ghosh (2016) conducted an empirical investigation aimed at elucidating the biomechanical influence of upper and lower limb segment lengths, as well as upper limb muscular strength, on the velocity of ball release among cricket bowlers. The study sample consisted of twelve slow-to-medium pace bowlers, aged between 20 and 30 years, selected from various First Division Clubs within the Kolkata league governed by the Cricket Association of Bengal (C.A.B). Additionally, kinematic data from 31 bowlers (mean age = 23.17 ± 3.95 years; mean height = 172.04 ± 5.88 cm; mean body mass = 62.79 ± 7.23 kg) were captured using dual fixed-position cameras. The footage was digitized, and motion variables were analyzed using Kinovea software version 0.8.24. Statistical processing of the data involved the computation of central tendencies and dispersions (mean and standard deviation), followed by Pearson's Product-Moment Correlation analysis to evaluate inter-variable relationships. The findings indicated a statistically significant positive correlation between arm length (77.79 ± 3.33 cm), leg length (90.62 ± 3.71 cm), and arm strength (44.09 ± 6.50 kg) with ball release velocity (106.77 ± 7.61 km/h), corresponding to correlation coefficients of r = 0.598, 0.587, and 0.722 respectively. These results substantiate the assertion that both limb dimensions and upper limb strength are critical biomechanical predictors of ball release velocity in cricket bowling mechanics.

Pion et al. (2014) undertook a comprehensive investigation involving 22 evaluative assessments encompassing anthropometric measurements, physical fitness indices, and motor coordination tests, all of which exhibited a high discriminant capacity for classifying young athletes into their respective sporting disciplines. The study sampled 141 male participants representing nine distinct sports disciplines—namely badminton, basketball, gymnastics, handball, judo, soccer, table tennis, triathlon, and volleyball. Utilizing discriminant function analysis, both athletes and non-athletes were categorized based on performance aptitude and physiological profiles. The statistical analysis yielded a high degree of accuracy, with 96.4% of the total participant cohort correctly classified into their corresponding sports categories. When the analysis was confined to discipline-specific performance determinants, classification accuracy ranged between 80.1% and 97.2% across the sports. Key variables demonstrating the highest discriminatory influence included: flexibility, which was paramount in gymnastics; explosive lower-limb power, which significantly contributed to classification in badminton and volleyball; and a combination of speed and agility, which were pivotal for differentiating participants in badminton, judo, soccer, and volleyball. Additionally, upper-body muscular strength emerged as a strong predictor in badminton, basketball, and gymnastics, while cardiorespiratory endurance was notably relevant for athletes in triathlon. Furthermore, specific technical competencies such as dribbling proficiency proved to be salient in handball, basketball, and soccer, and overhead-throwing ability served as a discriminative factor in both badminton and volleyball. This study underscores the utility of multidimensional profiling in sports talent identification and classification.

Sidhu, Jagdev Singh (2012) executed a quantitative investigation aimed at evaluating the predictive validity of selected anthropometric and physical fitness parameters in relation to the on-field performance of university-level male hockey players. The research sample comprised 200 athletes, all of whom had participated in North Zone inter-university hockey competitions. Participants were stratified based on their specific playing positions—namely forwards, half-backs, full-backs, and goalkeepers—to facilitate position-wise performance analysis. Statistical analysis focused primarily on correlation coefficients to determine the strength and significance of relationships between anthropometric traits and performance metrics. The findings revealed that standing height and total arm length demonstrated a statistically significant and positively correlated relationship with hockey performance, with significance confirmed at the 0.05 level. Conversely, although body weight showed a positive trend, its

correlation with performance outcomes was statistically non-significant. The results underscore the influence of vertical stature and upper limb reach as advantageous biomechanical attributes that likely enhance stick handling, reach, and spatial control during gameplay. Other examined variables, which failed to reach statistical significance, were deemed to have minimal predictive value. In conclusion, the study substantiates that standing height and total arm length function as reliable anthropometric indicators of performance efficacy among university-level field hockey players, thereby offering potential value for talent identification and positional placement strategies.

CHAPTER III

METHODOLOGY

SELECTION OF SUBJECTS

For the purpose of this research, a purposive sampling method will be employed to select 60 male badminton athletes, comprising 30 singles specialists and 30 doubles specialists. The selection will be based on the following eligibility criteria:

1. Participants must be within the age bracket of 18 to 25 years.
2. Only those who have competed at the national level will be considered.
3. Athletes should possess a minimum of five years of playing and/or structured training experience.
4. Individuals must be free from any physical injuries or psychological conditions that could interfere with the data collection process.

SELECTION OF VARIABLES

The following variables will be selected for the study:

Physical:

- Body Height
- Arm Length
- Leg Length
- Reaction time
- Flexibility
- Shoulder strength
- Explosive leg strength
- Grip Strength

- Thumb Pinch

Physiological

- Body Composition (Fat%, Muscles mass)

Psychological

- Anxiety
- Emotion regulation

CRITERION MEASURES

Category	Variables	Instruments	Units
Physical	Body Height	Stadiometer	Centimeters
	Arm Length	Anthropometer Rod	Centimeters
	Leg Length	Anthropometer Rod	Centimeters
	Reaction Time	Penny Cup Test	Seconds
	Flexibility	Sit and Reach test	Centimeters
	Shoulder Strength	Medicine Ball Throw	Meters
	Leg Explosive Strength	Vertical Jump	Centimeters
	Grip Strength	Hand Grip Dynamometer	Kilogram
	Thumb Pinch	Pinch Dynamometer	Kilogram
Physiological	Body Composition	Maltros Bioscan.916	Kilogram
Psychological	Anxiety	Sports Competition Anxiety Test (SCAT)	-
	Emotion Regulation	Emotional Regulation Questionnaire (ERQ)	-

DATA COLLECTION

Body Height

To ascertain the height of the individual, they will be instructed to stand upright, barefoot, on a level horizontal surface of the stadiometer, ensuring that their heels, the back of their shoulders, and their head make contact with the rod of the stadiometer. The measurement will be documented in centimeters. The measurement will be documented to the nearest tenth of a centimeter.

Arm Length

The measurement will be conducted utilizing the anthropometer rod. The measurement from the acromion to the dactylic point. The participant will be instructed to assume a comfortable stance. One end of the anthropometer will be secured at the acromion point, while the other will be calibrated to the dactylic point. The measurement will be documented to the nearest tenth of a centimeter.

Leg Length

The distance from the anterior superior iliac spine to the standing surface will be measured using an anthropometric rod, with the individual positioned identically to that used for stature measurement. The length of the leg will be measured with an anthropometer rod, accurate to the nearest 1/10th of a centimeter.

Reaction Time

The participants position themselves at the starting line, facing away from the cups, with a penny in one hand. Upon the starting signal, he pivots and sprints towards the cups. Upon crossing the signal line, he receives a directive from the tester. He proceeds to the cup signaled by the directional indicator and deposits the penny into that cup.

Flexibility

The assistant affixes the ruler to the box top with tape, ensuring that the front edge of the box aligns with the 15 cm (6 inches) mark on the ruler, while the zero end of the ruler faces the athlete. The athlete is seated on the floor with their legs completely extended, the soles of their bare feet resting against the box. The athlete positions one hand atop the other, gradually leans forward, and extends along the ruler's length as far as possible, maintaining the stretch for two seconds. The assistant measures the distance attained by the athlete's fingertips (cm). The athlete executes the test thrice. The assistant computes and documents the mean of the three distances and used this figure to evaluate the athlete's performance.

Shoulder Strength

To assess shoulder strength, participants will be instructed to throw a medicine ball forward while seated with their legs extended both in front of and alongside their body. This exercise is referred to as the front medicine ball toss. The subjects attempted to oscillate both arms forward and backward to propel the medicine ball as far as feasible. The highest score among the three attempts is documented as the performance.

Leg Explosive Strength

A vertical jump test will be employed for measurement. The athlete positions themselves laterally against a wall and extends the hand nearest to the wall upward. The fingertips' points are identified and documented while maintaining the feet flat on the ground. This measurement is referred to as the standing reach height. The athlete thereafter positions themselves away from the wall and executes a vertical leap, reaching maximum height. An effort will be made to contact the wall at its apex. The score represents the disparity between the standing reach height and the jump height. The highest of the three scores is documented.

Grip Strength

The assessment will be conducted using a grip dynamometer. The individual grasps the dynamometer with the arm positioned perpendicularly and the elbow adjacent to the torso. The dynamometer's handle is adjusted as necessary; the base must be positioned on the first metacarpal (the palm's heel), while the handle should align with the midpoint of the four fingers. Upon readiness, the participant exerts maximum isometric force on the dynamometer, sustaining this effort for approximately 5 seconds. All other bodily movements are prohibited. The highest score from the three attempts is considered the final score.

Thumb Pinch

The assessment will be conducted using a pinch dynamometer. The subject will be instructed to sit comfortably, with the shoulder adducted and the elbow flexed at a 90-degree angle (parallel to the ground). He will subsequently be instructed to grasp the dynamometer with his thumb. The highest score among the three attempts is considered the final score.

Body Composition

The Maltros Bioscan will evaluate body composition. The individual will remove their shoes and assume a supine position, after which the researcher will affix two electrodes to the right foot, positioning one electrode centrally and the other at the ankle between the medial and lateral malleoli. The configuration of electrodes on the right hand will involve positioning the first electrode centrally, directly beneath the third knuckle of the middle finger, and placing the second electrode on the wrist adjacent to the ulnar head. Subsequently, two alligator clips will be affixed to the hand and two to the foot, connected to the electrodes. Upon activating the bio scan machine, the researcher will input specific data regarding the subject, such as age, weight, and continent, after which the results will be displayed on the screen.

Anxiety

The evaluation will be conducted using a questionnaire known as the Sports Competition Anxiety Test (SCAT). This test, created by Martens (1977), is a self-report questionnaire consisting of 15 questions that evaluate an athlete's anxiety by assessing their reactions to various statements regarding their feelings in competitive scenarios. Based on their responses, the test administrator can classify their anxiety level as low, moderate, or high. The reliability coefficient for this test is 0.77.

Emotional Regulation

The Emotion control Questionnaire, created by Gross and John, aims to evaluate individual variances in the regular application of two emotion control strategies: cognitive reappraisal and expressive suppression. The assessment has 10 questions that will explore the individual's emotional life, specifically focusing on their ability to regulate and manage their emotions. The inquiries pertain to two separate facets of emotional existence. One is an emotional experience, or the inward sensations they evoke. The other aspect is emotional expression, which pertains to the manner in which individuals convey their emotions through speech, gestures, or behavior. Each item will be evaluated on a 7-point scale, ranging from strongly disagree to strongly agree.

STATISTICAL ANALYSIS

The collected data for this study will be examined using the following statistical methods:

- **Descriptive statistical tools** will be utilized to summarize and interpret the characteristics of the badminton players across different groups. Measures such as mean, skewness, and kurtosis will be calculated to understand the distribution and central tendencies of the variables.
- **Multiple discriminant analysis** will be employed to categorize participants into either of the two groups (singles or doubles) based on the selected predictor variables.

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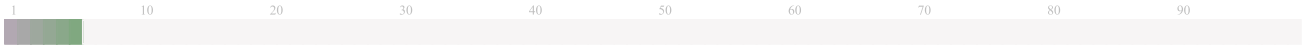

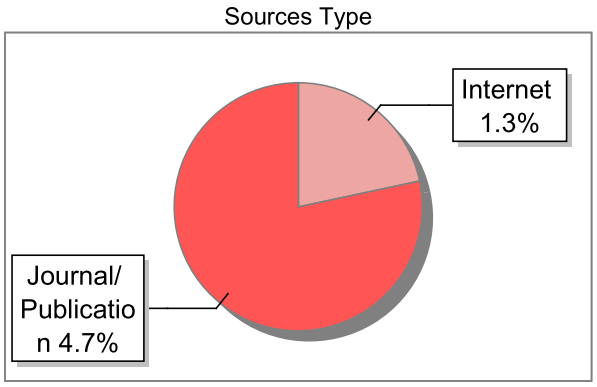

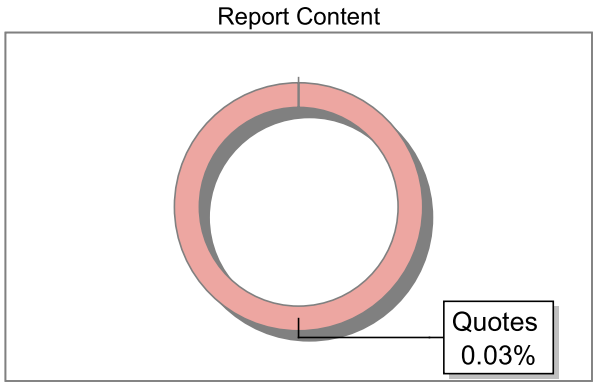

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